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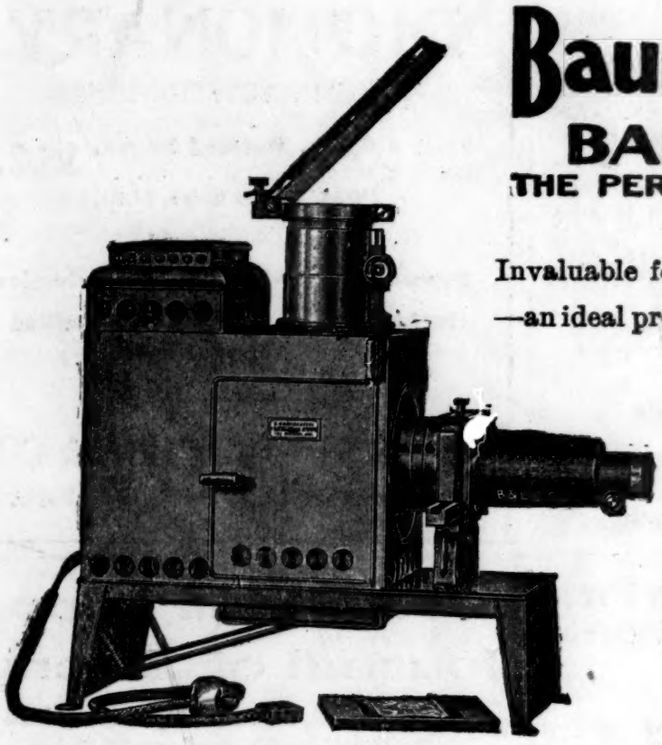

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SCIENCE

FRIDAY, OCTOBER 25, 1918

CONTENTS

The Trained Man of Science in the War: PROFESSOR J. S. AMES 401

Lieutenant Herbert Douglas Taylor: T. M. P. 411

Scientific Events:—

Appointments at the New York State College of Agriculture at Cornell University; The Influenza Epidemic; The Baltimore Meeting of the American Association for the Advancement of Science 411

Scientific Notes and News 414

University and Educational News 417

Discussion and Correspondence:—

Mr. Abbot's Theory of the Pyrheliometer: FRANK H. BIGELOW. *Fireflies flashing in Unison:* FREMONT MORSE 417

Scientific Books:—

Grant on the Passing of the Great Race: DR. FREDERICK ADAMS WOODS. *Taylor on War Bread:* PROFESSOR GRAHAM LUSK 419

A Study of Engineering Education 420

Two New Anthropological Journals: F. B... 421

Special Articles:—

The Relation of the Plant to the Reaction of the Nutrient Solution: D. R. HOAGLAND. *An Electro-Thermo-Regulator for Water Baths:* CHAS. H. OTIS 422

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THE TRAINED MAN OF SCIENCE IN THE WAR[1]

THE motto of our society, as our newly initiated members now know, is one by following which unconsciously they have won admission to it: "The love of learning is the guide of life." It must have occurred to you all to ask how can this assertion be true in times like these. That an answer may be given easily is evident if we remember the circumstances under which the society was founded, at the College of William and Mary, in the midst of the Revolution. Our ancestors were engaged in a struggle for the freedom of the individual, the freedom of the soul; so are we to-day. They had entered this entirely unprepared; so did we. They were faced with difficulties which seemed at times unsurmountable; our obstacles to victory are no less formidable. The Phi Beta Kappa Society owes its origin to a recognition on the part of its founders and supporters of two great facts: the importance to the individual of the love of learning and the responsibility resting upon him as an educated man to serve his country.

I think it is only fair to say that the universities of this country have played their part well. Before we actually entered this war, in those anxious years when we were waiting to see whether we would be given an opportunity to join in the fight for the cause of honor, freedom and the teachings of Christianity, or whether we must walk through the years of our lives with heads hung in disgrace, no group of people did as much to hold aloft the illuminating torch, revealing the iniquity of the enemy of civilization, as did the presidents of our universities. Theirs will be the honor forever. They would not keep silent. Then, as soon as we were by official act in a state of war, the first to step forward and say "use

[1] Annual address before the Phi Beta Kappa Society, University of Virginia, 1918.

me" were the faculties and the student bodies. It was indeed a sight which brought tears to the eyes, and even further, to see our young men, the chosen men of our land, struggle against all restraints, eager to bring to an end that evil thing which threatened to destroy all the joy of life, all that made life worth living. Every teacher has felt thrilled by the daily farewells of his students, as one by one has obtained permission, by fair means or otherwise, to enlist in the grand adventure. We men associated with universities may well be proud.

Think for a moment what unutterable shame would have been ours if we had not acted with such certainty and such promptness. Every privilege brings its responsibility. It is a privilege to acquire an education and to share in imparting one. The country as a whole has grown to recognize this, and to look to the universities and to men trained in universities for advice, if not for guidance. It is the privilege of being a young man to-day, a college man or not, to be a soldier in the cause of civilization and to help bring victory to its colors; and what a glorious privilege this is! But upon whom rests the duty of interpreting events and their causes in language so clear that every man understands? Surely, upon the university man. And, when victory is won and men can give their minds to thoughts of safeguarding the world, there is no one to guide them but the students of history and of political science. It would be a simple matter to show how a special and particular responsibility has already come to and will continue to remain with each and every university group of scholars. I can speak with more definite knowledge of the relation borne by various branches of science with the war; and it is to this feature that I shall confine myself to-night.

A recent writer has alleged that the study of science at the expense of morals in German universities has led to this war. This is a bitter charge, but it is supported only by fallacies. Macaulay, in his brilliant essay on Dryden, shows, by a series of striking illustrations, how little is the influence upon the age of any individual, or any special group of individuals, when compared with the influence of the age on the man or group. When the time is ripe, the idea is born; the special man who reveals it is immaterial. So it is to-day, no one man, no particular department of thought or study can be held responsible for the present conditions in Europe. It is no more fair to say that the pursuit of science perverts character than to assert that the study of morals results in ennobling it. This war is due to a gradual debasement of character and nothing else, and the cause is to be sought in the will of the leaders of Germany.

One reason why science has been thought of as the scapegoat is because it was so evident from the very beginning of the war that Germany had mobilized for the purpose of war all her men of science, and was using the fruits of their investigations in ways entirely unexpected. This was a matter of great surprise to most Americans, and illustrates clearly the comparatively insignificant position held by scientific men in the minds of our people. This feature of Germany's long preparation for war, and of her manner of waging it was recognized instantly; and preparations to combat it were made promptly by all the allied peoples. Fortunately for us, the essential advantages were all with the French and British, inasmuch as their men of science had for nearly a generation been the ones who had given to the world its great discoveries and their most important applications. So their scientists came to the problems with ideas and methods which in many cases far surpassed the power of Germany to equal. The result was instantaneous; and to-day the efficiency of the forces of the Allies on the sea, on the land and in the air is due in no small degree to the men whose previous lives had been devoted to the pursuit of the pure sciences in university laboratories.

When this country entered the war, it is true beyond any doubt that the American people had great expectations, nay a conviction, that with our so-called inventive genius we would seriously influence the war, perhaps stop it, by the epoch-making inventions which our professional, highly advertised, inventors

would quickly make. The newspapers helped in fostering this belief, and many were the proud boasts which we heard. There was a great disappointment, almost a shock, as the days went by, the periods promised for great accomplishment passed, and certain names almost disappeared from the public press. We have in fact stopped asking what has happened to the "wizards." The reason is that the problem of this war is not to perfect an old device, but to design a new one; the knowledge required is not that of the amateur or even of the trained engineer, but definitely that of the scientific investigator, the man who by his own laboratory investigations has added to our store of knowledge. One illustration of this may suffice; one government board, with whose activity I am familiar, has had submitted to it in the course of the year 16,000 projects and devices, proposed by so-called inventors; of these only five had sufficient value to deserve encouragement. I have nothing but admiration for these 15,995 men, whose disappointment must have been keen. Most of them were more than willing to give their inventions freely to the government. The point I wish to emphasize is that the ability and knowledge required in waging this war successfully are not those possessed by any body of men except those with a profound knowledge of science and of scientific method. The problems are too complicated. It is true that with the help of trained technical men we will get better engines, better explosives, better guns; and for these we should be truly grateful to our much-boasted American genius. But, consider a problem like this: to devise a light signal, which can be used by day or by night, and which will be absolutely invisible to the enemy. Who can solve that? The answer is obvious: only a physicist.

In times of peace, when commercial development is uppermost in men's minds, the university scholar is at a great disadvantage. He rarely knows what problem is to be solved. He is busy with his own studies and researches, and does not come in contact, in the ordinary course of his life, with the demands of the technical trades. His discoveries are made use of, and are always—sooner or later—of commercial value; but in this later stage he does not take part. Nearly all of our great technical companies maintain extensive laboratories where trained men pursue investigations in pure science; but problems are rarely given them to solve. To-day, in order to meet the insistent demands of the war, the whole process is changed. On every battle front of Europe, attached to the various staffs, are men from university faculties, skilled in observing, quick to learn what is needed. In Paris, London and Rome there are groups of university men whose duty it is to collect data from the Allied powers along similar lines. Reports containing clear statements of the problems are cabled to Washington. To this same center come requests for help from our own forces on this side of the ocean. Then, as soon as the problem can be formulated with definiteness, one or more men are asked to find the solution. For the first time in the history of science, men who are devoting their lives to it have an immediate opportunity of proving their worth to their country. It is a wonderful moment; and the universities of this country are seizing it. The stimulus to scientific work is simply enormous; and the growth of our knowledge is astounding. In many cases investigations are prolonged for months, and in the end possibly the much desired solution is not obtained; but in any case new methods are made available for future use, new instruments are perfected, and the store of human knowledge is vastly increased. Let me give one illustration of this reaction of the demands of war upon pure research. In the construction of a mask to be used in case of a gas-attack it is obvious that one method of defense is to make use of charcoal which is known to absorb many gases with great rapidity. A scientific problem was to try to increase the efficiency of this absorbing action; and it was soon discovered that by a special treatment of charcoal made in special sizes from special wood the absorptive power could be increased enormously. Here is a fact of the greatest importance to the chemist, a fact which will be remembered in countless investi-

gations of the future; and yet it is doubtful if it would have been discovered for many years to come if a particular chemist had not been asked by the military officers to help them.

As I trust you have already discovered, my thesis to-night is the importance of the work of the trained man of science in this war, with emphasis upon the fact that his great usefulness should not be a matter of surprise, as it is to most Americans. The best way of demonstrating this is to give a few illustrations, chosen from a wide field and not limited to the scientific work of any one country. Naturally I can refer only to those matters which have been revealed to the public; but I trust that many of them will be new to this audience. I have this confidence because so far the newspapers of this country have not believed that these questions would make what is called a "story."

It is not easy to make a selection of the scientific problems, nor to arrange them in any logical order. There are two subjects uppermost in the minds of every one: the airplane and the submarine. The scientific questions which have arisen in regard to each are most varied. The airplane itself is an engineering structure; and we have confined ourselves in this country largely to the design and production of an engine. This does not really come under my general subject, but every one is so interested in it that I feel justified in referring briefly to what we have done. Our task was to produce on a great scale a powerful, efficient engine. This is now being done. The so-called Liberty 12-cylinder engine does not have its superior in the world, and further, it was so designed that it could be manufactured on an enormous scale, at least 1,500 a month. This engine has over 400 horse-power and weighs close to 800 pounds, and therefore it is useful for seaplanes, two-seater machines and bomb-droppers, but not for small machines. When the same engine is made with 6 cylinders, developing about 220 horse-power, and weighing about 400 pounds, we will have an ideal engine, not equalled by any now in existence, for speed scout machines. We could not have followed any plan more useful to ourselves and the Allies than to make this concentration of effort. Our eminent success is a cause of pride to every American. With regard to the airplanes, considered apart from their engines, a few statements of fact must suffice, but they are facts. The best airplanes in service to-day, for each and every purpose, are those of British and French design. This is the result of real scientific investigation. The resistance offered by wings of different sections, the stability of the airplane, the character of the covering surfaces have all been investigated, and the finished product is the result of the knowledge thus acquired. We are doing similar scientific work in this country to-day, and, as we have engineers and manufacturers unsurpassed in the world, the time is not long distant when a truly American airplane will be made. We shall suffer, however, one serious detriment during the war; we are so far away that it will be extremely difficult for us to make the alterations in design which the varying conditions of modern war impose. Difficulties of transportation are great, and it is a serious question whether it would not be best for us to remove bodily our most important airplane shops directly to the Continent. From a scientific standpoint the most important questions arising in connection with airplanes are instruments of navigation and methods of signalling to and from the ground and each other Each machine should have for ordinary flights an instrument to indicate height above the ground, another to give the speed of flight through the air, another to tell how steep is the ascent or the descent, and many others. For long-distance flights a compass is necessary, and other instruments as well. The design of each of these is a distinct scientific problem. Think of the requirements for a compass to be used with an airplane; for a ship on the ocean the problem is complicated, but how much more so for a vessel which turns rapidly, revolves in spirals, and which practically never keeps a constant course. In practise even more difficulties arise. The whole question of airplane instruments is still unsettled to a certain extent; many essential instruments have not as

yet been designed, and improvements are needed in them all. Scientific men in all countries, including our own, have the matter under study; and the results so far accomplished are truly wonderful. In the use of airplanes for observation purposes, or in squadron formation in making attacks, it is essential for the men in the machine to communicate with the ground. Many systems are in use, involving the application of light signals, wireless telegraph, etc. Obviously the proper instrument would be the wireless telephone, and that is surely coming, and soon it will be possible for one pilot to talk with another or with the commanding officer on the earth; and the latter can give orders to all of his machines in the air. The objection to the use of all forms of wireless apparatus, telegraph or telephone, is that the enemy may confuse the signals by using the same wave-length for his disturbing impulses. This may be prevented however. Under the demands of the modern army, all forms of wireless have been so perfected that the progress made is a source of surprise and wonder. In fact there have been made in this country certain modifications and improvements which are held rigidly secret. It is interesting to note that every one of these alterations in wireless operation was first worked out in physical laboratories, by trained physicists. Bomb dropping as practised to-day is not a scientific operation; there are too many variables. In spite of this, though, the accuracy of hits is increasing daily; and new processes are being developed. When it is seen that one method can not be made accurate, the next step is to devise one that will be. It will not be long before all the countries in the war will realize the fact that the tactics of fighting in the air are essentially unique, and there will be a land-service, a sea-service and an air-service. Both the army and the navy need airplanes for their operations; but after their demands are supplied, there remains the wide expanse of the air through which attacks can be made upon the enemy, far away from the battle-front and the coast. Great Britain has recognized this all-important fact, and is building a great fleet of airplanes for this new service. In this, new instruments, new types of machines, new guns and bombs are required.

There are two main problems in connection with the submarine, first to locate it, second to destroy it. Methods of destruction are at hand in the shape of depth bombs; but methods of detection so far have not been eminently successful. From an airplane one can see through the water only to a limited depth, never more than twenty feet, and so the main reason why the seaplanes have been so successful in destroying submarines is not due to the fact that the observer in the airplane discovers his prey, but is that his machine has such great speed, three times that of a destroyer, that when news is flashed that a vessel is being attacked by a submarine it can often reach the spot in time to drop its bomb effectively. The detection of the presence of a submarine is a definite physical problem; and it is not an exaggeration to say that at least one fourth of the physicists of note in England, France and this country have been engaged in the attempt to solve it. What lines of attack upon it are open? Not many. The submarine in motion emits certain sounds; can they be heard? It is a solid body; can one obtain an echo from it? It is made of iron; can this fact help through some magnetic action? These are the obvious lines of approach, but one should not hastily conclude that there are not others. Without stating, and I may not, how far successful these efforts of the physicists have been, I may note that the method which is now being tested by our Navy is one elaborated by a distinguished professor of mathematical physics. In the course of these extremely numerous experiments upon the submarine question several beautiful methods have been developed which after the war will have great scientific importance; one of these, due to a French physicist, is one of the most interesting developments in physics made within a decade. Another submarine problem, which is by no means of secondary importance, is to develop a method by which one submarine may communicate with another or with the shore. I do not think I

am saying too much when I state that this has been solved, even for considerable distances.

Closely associated with the airplane and the submarine is the balloon, either a dirigible or an observation one. The great problem here is to find a means of inflating it with some gas which is non-inflammable. Hydrogen is now used in general; and, when a balloon is brought down in flames, it means that the hydrogen has caught on fire. This problem is partly physical and partly chemical; and numerous experiments are now in progress, all being directed by university men.

I can not leave the subject of the airplane and the observation balloon without referring to the question of maps and map-making, in connection with which the former are so important. Until one has been at the headquarters of an army, it is not possible to realize the extent to which maps are used, or the various types of maps required. There are maps showing roads, paths and trenches; maps for staff officers, for regimental commanders, for company captains, for sergeants; there are maps showing the position of the enemy's ammunition dumps, aerodromes, signal stations, anti-aircraft guns; there are maps showing the location of the enemy's batteries; there are special maps for the use of the quartermaster, etc., showing where each horse trough, each well, each storehouse is. Map-making has long been a function of engineers; and in this war the most marked improvements have been in the main mechanical, first in introducting quickly on a map the revelations made by aerial photographs, second in increasing the speed of production of a map. In many cases, entirely new sets of maps are made each day, each one containing the information obtained within the preceding twelve hours.

Another department of science closely connected with airplanes and balloons is meteorology. We associate this word with weather prediction and with uninteresting data; but it must be remembered that these data include observations of temperature, of moisture content of the air, of air pressure, of wind direction and velocity at different heights above the earth. A knowledge of all of these is absolutely essential for each day's battle. Artillery at a long range is useless unless the temperature, the moisture content and the wind are known accurately. Gas attacks are controlled by the knowledge of winds and barometric pressure. The safe strata for airplanes must be known; and for long distance work weather prediction of every description is essential. So important is the subject that observation stations with competent forecasters and scientific observers dot the battle-front at close intervals; and the home offices send almost hourly reports to the fleets and the coast-stations. What strikes a layman most forcibly when inspecting a meteorological station near the battle-line is the rapidity of operation. Only minutes lapse between the observations and the deduction of the conclusion. One realizes then how much meteorology has grown into an exact science.

Modern artillery is a good illustration of the application of pure science. All of us are now familiar with the method by which artillery fire is controlled by the aid of airplanes; but you may not realize its wonderful accuracy. If the enemy's battery is located, by any means, this implies that its position on a topographic map is known to within, say, fifty feet, often less. It may be at a distance of ten, fifteen or more miles. Then to hit it, an exact knowledge of the properties of the powder used and of ballistics is required. With this, the target is reached in an astonishingly short time. I have witnessed myself the destruction of a German battery at a distance of eleven miles by a French battery of three thirteen-inch guns, all done within ten minutes, the exact aim being secured after three salvoes. The perfection of the mechanism of the French 75 and 37 millimeter guns is known to us all; but we hear much less of the English and American guns. I can assure you that this is only a curious bit of camouflage. Of all the numerous ways in which physics has been called in to assist artillery, I known none so interesting as is illustrated by anti-aircraft gunnery. The problem is most difficult. An airplane may be traveling at a

speed of 100 or 10 miles an hour, it rarely keeps a constant course, it may be at a height above the earth of 20,000 feet, nearly four miles. The man aiming the gun must know the position of the airplane and its speed, and then must make his calculations so that when his shell reaches the immense height, it shall be so timed as to meet the airplane. It is true that it is rather a question of the airplane meeting some fragment of the shell, than the converse; but the problem is the same. When it is realized that numerous hits are recorded at heights of 20,000 feet, and when one hears the personal experiences of the pilots, it is clear that the problem has been solved fairly well. A former student of mine writing to me a few days ago, after telling how he had "speared his first Hun" on his first day at the front, added that the German shells rarely missed him by more than ten feet, and he was flying a rapid scout machine and was manouvering for position all the time. I am familiar with the French and British methods of aiming their guns; and, as you can yourself decide from reading the newspapers, they are not inferior to the ones used by the Germans.

One can not speak of artillery without thinking of gas shells and gas attacks. The Germans were the first to use this hideous means of warfare, although it is well known that it was proposed to the British war office many years ago and the decision was reached that it should not be adopted. When poisonous gases first became a weapon, it was in the form of gas clouds, rolled along the ground by the wind, the gas having been released from cylinders in the front line of trenches. For perfectly obvious reasons this mode of gas attack was soon replaced by the use of large shells filled with the liquefied gas. When the shell was exploded by a contact- or a time-fuse, the gas would escape and work its action in all the neighborhood. There are two problems associated with this mode of warfare: an offensive and a defensive one. The former is to make a gas which can be liquefied, is not so light as to diffuse upward too rapidly, and which will either kill the man who breathes it or will in some way incapacitate him; the latter is to make a mask or a suit of clothing, if necessary, which will enable the wearer to breath and do his work in the contaminated atmosphere. We hear most of course about the terrors of the gases used by the Germans; but, if they would only describe to us their feelings about the gases sent them, our point of view would change. Some might even have a feeling of pity. Both the questions, of defense and offense, are strictly scientific ones, in the main belonging to chemistry. The researches undertaken in Great Britain, France and this country are so numerous that the truth is almost unbelievable. It is safe to say that to-day there are at least 2,000 chemists in America alone working on problems connected with the military use of gas. We can well be proud of the achievements of our chemists. Among many things which I may say I shall select two: they have devised a mask for use inside a gun turret on our large ships where a particularly dangerous gas is liberated during a battle, and the masks supplied our soldiers are at least 20 per cent. better than either the British or French mask, and they are better than the German model. As another illustration of the usefulness of chemists in this war, one should state what has been done by them to render the allied countries and our own independent of Germany from an economic standpoint. All I shall do, however, will be to mention two subjects: dye-stuffs and drugs; and you know the rest. It should be remembered, though, that this is not the full story, only an interesting chapter.

One of the most important military questions, which in the end is a purely physical one, is that of signals. Our army is most fortunate in having as its Chief Signal Officer a man who is a doctor of philosophy in physics, from Johns Hopkins University, Major General George O. Squier. He certainly knows his subject from the scientific standpoint as few military officers can know it. Think for a moment of the variety of signals required. Those to and from airplanes and submarines have been referred to. In addition, each trench, each outpost, each reserve force,

each artillery battery must be in unbroken communication with the brigade headquarters, and the division and staff officers. Wireless telegraphy and telephone are used in various ways; ordinary telephones are installed everywhere: carrier pigeons must be bred and trained; signals using both sound and light are most useful. It is not merely a matter of perfecting signals which work satisfactorily; much more is required, safeguards must be devised which make it impossible for the enemy to observe or read them. When I say that all this has been done, and done to a large degree by our American physicists, I am telling only the bare truth. I wish it were permitted to tell more.

Signals as used by the Navy are not as varied as those required by the Army. But there is one special problem which concerns the American Navy more than any other. We are sending ships and transports to Europe in large groups, as you know, and at night no lights are shown by any vessel; the question then arises, how is it possible to maintain relative distances and positions? This sounds as if it were an almost hopeless proposition; but it is not; and I have seen a solution which seems satisfactory, again the ingenious idea of an American physicist.

The demands upon photography are great, largely in connection with airplanes; and the methods elaborated by the British and French scientists are beautiful. There are other phases, though, of almost equal importance. Can we not take photographs of objects which the eye can not see, owing to clouds, haze or distance? This matter is solved in a large degree as a result of our spectroscopic knowledge. By photographic methods it is possible to discover the location of the enemy's batteries unless they are hidden with the utmost care. In this last case resort is had, as you know, to what is called sound-ranging. When a gun ejects its shell in the direction of the enemy, the latter hears in succession three sounds; first that due to the passing of the shell through the air, in general a hissing sound; then the proper sound from the gun mouth, a boom; and finally the sound of the explosion of the shell. Sound waves travel through the air with a comparatively slow velocity, slightly over 1,000 feet per second, and so if observing stations are placed at different distances from the gun, any one type of the three sounds, *e. g.*, the boom, will be heard at different instants of time. It is easily seen, then, that methods may be devised by means of a system of triangulation, by which the location of the gun may be determined. The accuracy of the methods in use is so great that now within a few minutes after the firing of a gun its position is known definitely to within limits less the accuracy of the guns which are responsible for the destruction of the enemy's battery. This last limitation is due to an unavoidable variation in shells and their powder charges, and to variations in the atmosphere. This method of sound-ranging is simple in theory, but extremely difficult in practise, owing to vagaries of the wind and to the confusion caused by simultaneous discharges of guns. The former difficulty has been overcome by a brilliant British physicist; but, as you have probably seen in the papers, one of the ways used by the Germans to conceal the position of its big guns by which they were bombarding Paris was to discharge a dozen other guns simultaneously.

A somewhat similar problem arises in connection with determining the position of an airplane at night, or in cloudy weather. One inherent difficulty here lies in the great speed and great height of the airplane. Rumors have reached us that the British have found a method; but, whether this is true or not, the problem is not hopeless. The airplane in flight emits sounds, loud ones; with that fact as a basis, its detection is therefore certain.

I am not sure that any of you would of your own account think of astronomy as being a practical science; yet there has been found a definite usefulness for these disturbances on the sun, known as sunspots; and astronomers easily turn from calculations of the motions of comets, planets and satellites to those of twelve-inch shells and bombs dropped from airplanes. The instruments used by navigators on the sea and in the air when the flights

are long are essentially those invented and adopted by astronomers. In fact an American astronomer has perfected within the past few months an entirely new instrument for the use of navigators, an instrument which will mean a great deal to both our sea and our air force.

Another science which seems remote from war is geology, and yet it has proved not simply useful, but essential. The minute you realize that this war is concerned with trenches, dugouts, military mines, tunnels, water-supply, etc., you see that here the geologist must be summoned to help. He alone knows from his maps, made in times of peace, how to plan for any emergency requiring one to go below the surface of the earth.

There is a group of sciences, not physical, which has, in the end, the greatest responsibility in bringing victory to our arms. The men who are directing the work, in the laboratory and in the field, are university men almost without exception. This group includes experimental psychology, medicine and surgery and hygiene. The function of the first of these is to devise such tests that we may be reasonably sure that a man selected for a certain duty can perform it. As a simple illustration, think of an airplane pilot. It is not difficult to analyze his responsibilities and to state the qualities which he should possess; further it is not impossible to devise experimental tests which may be performed on the ground in order to see if he has these qualities or, if not, to see whether he can acquire them in a short time. Our aviation section of the army has equipped laboratories along these lines, and the results obtained are most interesting. Certain generalizations will undoubtedly be deduced, and the examination of candidates can proceed more rapidly. As soon as our military departments can be persuaded to recognize the fact that experimental psychology can in many, if not all, cases state definitely that a man with such and such reactions ought not to command a company, a regiment or a ship, our fighting forces will become efficient, not before.

The varied activities of our medical departments are known to you all. When I think of them, what is uppermost in my mind is their progress in combating disease. I may be pardoned for speaking of two illustrations. The gas-bacillus, the cause of hospital gangrene, has lost its terrors absolutely; first by the Carrel-Dakin treatment of wounds, second by Dr. Bull's discovery of a serum which may be used exactly as diphtheria anti-toxin is used. Dr. Carrel is a Frenchman and Dr. Dakin is an Englishman; but both have lived long in this country; and Dr. Bull perfected his method at the Rockefeller Institute, New York. My second illustration is the discovery of the means by which trench fever is conveyed from patient to patient. This is not a dangerous disease, but is one which renders soldiers non-combatants for the time being. This discovery has just been made in France by two of our American doctors, both attached in normal times to American universities.

Time fails me to speak of any more of the ever-growing number of ways in which the men of science of all countries are helping the military arms. But, if I were to stop now, I would leave unanswered one question which I know is in your mind. You are probably saying to yourselves, "Yes, this is interesting to hear about the scientific achievements of ourselves and the Allies; but what is the real use of it, when Germany, which leads the world in all branches of science, is our enemy?" Now, let me say at the very beginning that no educated man, certainly no member of the Phi Beta Kappa Society should assert that Germany is the leader of the world in science. It is true that Germany modestly acknowledges it, and every American newspaper supports the claim in ways both direct and insidious. The facts, however, do not support it. Many years ago it undoubtedly was true, but a full generation has passed since then. The Prussian form of government does not encourage individuality or freedom of thought; and these are essential for scientific discoveries and scientific development. In all seriousness I maintain that Germany has not been fruitful in ideas for many years in any of the experimental sciences, with the exception of medicine. In the fields of physics, of chemistry,

of meteorology, of metallurgy, you must look for the leaders in other countries.

It may be true, although I doubt it, that Germany has the best generals, the best guns, the best ships; she certainly has the largest army and the power to bear upon any point the greatest force; but this condition will pass. In the meantime there are two agencies at work in this country which in reality are most powerful sources of German propaganda. One of these is the interpretation given to news from the war by our public journals, and the emphasis placed upon German successes. In part this is due to the lack of realization by the managers of the papers of their responsibility in the matter, but in larger part to that policy of a newspaper office which leaves the writing of the headlines in the hands of unexperienced, comparatively uneducated, young men. The other agency of German propaganda, and a much more vicious one, is the policy adopted by our own government in regard to giving out official information. The whole policy is wrong, and should be changed. The people have lost confidence in the government agents, and rightly so; they are either optimistic to a ridiculous degree or boastful. What is required is that the government must realize the tremendous responsibility of the office charged with the dissemination of news. There is no man in America too great for this task. He must command the absolute confidence of every one; he must be able to speak the truth and nothing but the truth; he must understand the thousand phases of the war, looked at from a military, a medical, a scientific, a social standpoint; above all he must be allowed to give the American people real information in regard to the efficiency, the achievements of our people and of the Allies. It is absolutely impossible for a man trained as a newspaper writer to grasp the situation. It is one of the real tragedies of the hour that the American people are so often deceived and are not told the truth about so many matters which concern them so vitally. If our people could only realize the exact situation, Germany would lose half her power, because in fact the American people are afraid of her, a condition which is absurd.

The scientific men of America have suffered greatly at the hands of the people. As I said at the beginning of this paper, it was a matter of great surprise to the country that science had any part in this war. Even such men as the members of the engineering societies have been slow to recognize the value of the service of the investigators in science. The ablest group of scientists in America is naturally the National Academy of Sciences, and the physicists are associated in a large and powerful American Physical Society; yet, when a few years ago one of our government departments determined very wisely to form a board of professional scientific and technical advisers, neither of these national societies was invited to name a delegate or to participate in any way. It was not understood clearly why the American Mathematical Society was requested to name a member of this board until it was explained that it was thought it might be useful to have a man who could do figures for them. This was of course simply a case where the general ignorance of the country was crystallized in action.

The time has come for America to recognize the usefulness of the scholar, the thinker, the investigator of science. All the other countries of the world have done so long since. It is only in regard to such experimental sciences as physics and chemistry that there is this failure in this country to appreciate the services of its experts. If the question as to the prevalence of a particular disease in army camps is to be investigated, a board consisting of pathologists and men skilled in hygiene is selected almost automatically, not a board of practitioners. The same is true in regard to all questions of public health, of social questions, of law. It is the duty of all college and university men to make their voices heard and to bear witness to what their teachers and their associates have done and are doing.

To return to our motto; the love of learning is a good guide for life; it brings its own happiness, it makes one a useful citizen both in times of peace and in war, it prepares a man for that service which is our only justification for living.

J. S. Ames
The Johns Hopkins University

LIEUTENANT HERBERT DOUGLAS TAYLOR

LIEUTENANT HERBERT DOUGLAS TAYLOR, M. C., U. S. Army, associate in pathology and bacteriology of the Rockefeller Institute for Medical Research, died on October 7, 1918, at the age of thirty.

Lieutenant Taylor was a graduate of St. Johns College, Annapolis, Maryland, and received his degree in medicine at the Johns Hopkins Hospital in 1914. During the three and one half years of his association with the Rockefeller Institute, he had made many important studies and published several papers especially relating to malignant tumors, tuberculosis and bio-chemical problems involved in the safer and more effective use of antiseptics in military surgery. Dr. Taylor was one of the group of younger workers at the Rockefeller Institute who at large personal sacrifice have chosen the pathway of research and in the emergencies of war have bent every energy to practical medical aspects of military service. Commissioned as first lieutenant soon after the entrance of this country into the war, he gave himself without reserve to the instruction of medical officers of the U. S. Army and others at the War Demonstration Hospital and in the Institute Laboratory courses, in those phases of scientific medicine of which he was master.

In the course of his duties at the hospital he apparently became infected with influenza with the immediate supervention of pneumonia, from which he died on the third day. He was a man of lofty ideals, of boundless enthusiasm in his tasks and an inspiring comrade.

T. M. P.

SCIENTIFIC EVENTS

APPOINTMENTS AT THE NEW YORK STATE COLLEGE OF AGRICULTURE AT CORNELL UNIVERSITY

AT the New York State College of Agriculture at Cornell University Ezra Dwight Sanderson has been appointed to be professor of rural organization. He was graduated from the Michigan Agricultural College with the degree of bachelor of science in the late nineties. He spent a brief time immediately after graduating at Cornell as a special student in entomology and for some years thereafter was engaged in entomological work in Delaware, Texas, and New Hampshire. In 1907 he was made director of the New Hampshire Agricultural Experiment Station, which position he held until 1910 when he left to become dean of the College of Agriculture of West Virginia University and director of the West Virginia Agricultural Experiment Station. In June, 1915, he resigned the latter position to enter the graduate school of the University of Chicago as a student in sociology and he was subsequently made a fellow in sociology at the University of Chicago. He is a member of the Society of Sigma Xi, one time president of the Association of Economic Entomologists and fellow of the American Association for the Advancement of Science. His work at Cornell will lie broadly in the field of rural social organization. This is the beginning of definite provision at the State College for the social problems in country life.

Homer C. Thompson has been appointed to be professor of vegetable gardening. Professor Thompson was graduated from the Ohio State University with the degree of bachelor of science in horticulture in June, 1909. Prior to this he had been employed in the United States Department of Agriculture in experimental gardens and had charge of experimental work on rice lands in South Carolina. During his last year in college he held the position of assistant in horticulture and subsequently held positions as assistant horticulturist in the Mississippi Experiment Station and assistant professor of horticulture in the Mississippi Agricultural College and professor of horticulture at Clemsen College, South Carolina; in 1911 he was appointed assistant horticulturist in the United States Department of Agriculture, and in 1912 was given charge of the truck crop production projects of the department and he has had responsibility for them since that time. In 1913 he was promoted to the position of horticulturist in the United States Department of Agriculture. Professor Thompson has had opportunity to study the production of vegetables in prac-

tically all sections of the United States and has directed the government's experimental work on truck crop production and storage. He has published a number of government bulletins in his field. He is a member of the American Association for the Advancement of Science, the Society for Horticultural Science and the Botanical Society of Washington.

THE INFLUENZA EPIDEMIC

The Bureau of the Census supplies the following information concerning deaths (still-

City	Estimated Population July 1, 1917[1]	Death Rate Week Ending Oct. 12[2]	Deaths from Influenza During Week Ending					Deaths from Pneumonia (All Forms) During Week Ending				
			September			October		September			October	
			14	21	28	5	12	14	21	28	5	12
Albany	106,632	37.7					34	2	0	2	2	11
Atlanta	196,144	21.8					5	7	a	4	7	25
Baltimore	594,637	69.5				30	192	7	6	19	87	371
Birmingham	189,716	22.3						3	a	2	12	30
Boston	767,813	87.3	19	172	600	991	850	27	93	175	225	177
Buffalo	475,781	37.6				7	82	8	11	16	41	98
Cambridge	114,293	66.2			82	113	100	7	4	23	27	15
Chicago	2,547,201	33.7			17	171	571	15	24	74	246	476
Cincinnati	414,248	24.4				3	47	5	4	6	15	20
Cleveland	691,251	14.2				3	18	5	8	10	15	22
Columbus	220,035	23.7					15	1	4	6	10	13
Dayton	128,939	24.3					20	2	1	2	5	11
Denver	268,439	21.2						3	3	8	19	a
Fall River	129,828	100.4				86	192	0	5	6	11	a
Grand Rapids	132,861	11.8						2	a	1	3	a
Indianapolis	283,119	23.0						3	6	10	24	a
Jersey City	312,557	52.9				16	87	2	6	21	b	a
Kansas City, Mo.	305,816	28.3				26	75	5	a	10	11	a
Los Angeles	535,485	14.9						9	a	2	14	a
Louisville	240,808	36.8						3	9	4	14	a
Lowell	114,366	89.8			16	29	37	1	8	16	64	104
Memphis	151,877	43.3					13	a	a	a	a	67
Milwaukee	445,008	19.7					15	4	5	13	15	54
Minneapolis	373,448	17.5					37	2	a	11	13	a
Nashville	118,136	78.6						2	a	3	5	29
Newark	418,789	37.1				31	119	a	a	a	a	70
New Haven	152,275	41.8			11	30	68	0	2	4	6	a
New Orleans	377,010	36.7				12		5	a	3	17	a
New York	5,737,492	30.1				299	979	74	98	145	434	1,642
Oakland	206,405	11.9						4	0	2	3	a
Omaha	177,777	27.3						1	a	2	7	a
Philadelphia	1,735,514	97.2				399	1,697	20	32	76	307	938
Pittsburgh	586,196	30.2						12	17	a	a	a
Portland, Oreg.	308,399	7.4						4	a	3	3	a
Providence	259,895	52.4				61	125	4	10	20	37	57
Richmond	158,702	58.5						4	2	3	a	a
Rochester	264,714	21.7					14	1	1	7	6	22
St. Louis	768,630	15.9					40	12	13	20	25	46
St. Paul	252,465	19.0					31	3	a	3	1	a
San Francisco	471,023	14.6						6	14	15	15	a
Seattle	366,445	17.9					54	4	2	4	a	a
Spokane	157,656	8.9						2	a	1	1	a
Syracuse	158,514	90.1			38	125	216	0	a	b	14	3
Toledo	202,010	16.5					2	2	0	5	3	7
Washington, D. C.	369,282	86.7			12	116	387	10	a	17	57	101

[1] Populations have been estimated by the arithmetical method. Owing to recent unusual migrations of the population and to the fact that 1917 is far away from the last census year, the estimates are probably too high in some cases and too low in others.

[2] These rates represent annual rates per 1,000 estimated population. [a] Not reported.

births excluded) reported during the week ending October 12, 1918, with death rates, in large cities of the United States, together with the number of deaths from influenza and pneumonia occurring in the course of five weeks.

THE BALTIMORE MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE meeting of the American Association for the Advancement of Science and of the national scientific societies affiliated with it, which it has been planned to hold this year in Boston has been transferred to Baltimore in order to reduce as much as possible the need for traveling and to be near Washington, which has become the center of scientific activity of the country. It is planned that the programs of the association and of the affiliated societies shall be mainly directed to questions of national welfare, national efficiency and national defense; they will demonstrate the value of science and of the work of scientific men to the country in the present emergency. It may be expected that through conferences which at the time can not be made public, direct contributions will be made that will be of service in the conduct of the war.

Dr. L. O. Howard, the permanent secretary of the association, under the date of October 16, addressed the following letter to the secretaries of the affiliated societies.

Something of a complication has arisen in connection with the meetings of the American Association for the Advancement of Science and the affiliated societies:

The Johns Hopkins University has taken on the Students Army Training Corps and, therefore, its courses are largely revised and its faculty is very busy. Their Christmas vacation runs only from the 22d to the 29th of December, both dates inclusive.

I had expected to be able to utilize the facilities of Goucher College, but this institution has now been closed by the epidemic of influenza and will probably have to be in session during Christmas week.

The present situation leaves for our meeting dates the 23d and 24th (then comes Christmas Day) and the 26th to the 28th, these being the only dates in which certain of the lecture rooms of Johns Hopkins can be used by us.

The committee on policy of the association has decided to adhere to its decision to meet in Baltimore, but there must be some change in plans, both on account of the small size and number of lecture rooms available and the fact that there are practically no hotel accommodations. Members will have to rely almost entirely upon lodging-houses, hence it becomes practically necessary that the meeting be a small one, but we will go ahead and do what we can.

With this understanding, will you please let me know if you still wish to meet in Baltimore and whether, in your opinion, you can make your meeting a small one devoted largely to immediate problems? And then, will you let me know so soon as possible the number and size of rooms you will need and everything which should go into the program? Please let me know also the dates which you will choose for your meetings.

It is obvious that for certain of the affiliated societies the 23d and 24th should be selected and, for others, the 26th to the 28th, since rooms vacated on the night of the 24th can be used by members of the affiliated societies meeting on the 26th to the 28th.

It is planned to have the opening meeting of the American Association on the night of Thursday, December 26, although meetings of the sections may be held during the day of the 26th.

I shall be glad to hear from you speedily as practically the whole arrangements for the meeting will be in the hands of this office since we can not place any of the burden on the Johns Hopkins' people under the present circumstances.

If you have some good member of your society resident in Baltimore to whom you wish to entrust your special arrangements, please tell me and let me know his name; otherwise, please state distinctly whether you wish this office to make all arrangements for you.

I wish to repeat that I should like to receive your answer as soon as possible.

SCIENTIFIC NOTES AND NEWS

The following officers of the Medical Corps, U. S. A., have been promoted from major to lieutenant-colonel: Edward J. G. Beardsley, Philadelphia; Thomas P. Lloyd, Shreveport, La.; James A. Mattison, Hot Springs, S. D.; Joseph Sailer, Philadelphia; Oliver H. Campbell, St. Louis; Bertram F. Alden, San Francisco; Walter W. Crawford, Hattiesburg, Miss.; Jonathan E. Burns, Baltimore; Charles N. B. Camac, New York; William C. LeCompte, Bristol, Pa.; Harry T. Summersgill, San Francisco; Charles H. Schlichter, Elizabeth, N. J.; Edward W. Pinkham, New York; William J. Bell, Washington, D. C.; Warren A. Dennis, St. Paul; Joshua C. Hubbard, John H. Blackburn, Bowling Green, Ky.; Edmund J. Doering, Chicago; John E. Jennings, Brooklyn; William W. Percy, Rochester, N. Y.; John H. Blackburn. Bowling Green, Ky.; Edmund Moss, New Orleans; Henry R. Brown, Albuquerque, N. M.; Robert Smart, Coronado, Calif.; Herbert H. Smith, Highland, Kan.

Colonel Edward L. Munson, for twenty-five years an officer of the Medical Corps, U. S. A., has been promoted to the rank of brigadier-general, and with the promotion selected for duty on the general staff. The new commission is in the line of the army. General Munson is the third medical officer of the army to be given general officer's rank for duty outside the Medical Department of the army, the previous appointees being Generals Ainsworth and Leonard Wood.

Recall to the active list of Major-General William C. Gorgas, former Surgeon-General of the army, who recently was retired for age, and his assignment to active duty in the same rank of the Medical Corps has been announced by Secretary Baker. General Gorgas will complete the inspection of medical conditions in France and England, on which he now is engaged, and then will return to the United States to submit a report. His next assignment may take him to Italy.

Lieutenant-Colonel Frank P. Underhill, professor of experimental medicine at Yale University, in charge of the New Haven Station, Chemical Warfare Service, has arrived safely overseas. Lieutenant-Colonel Underhill is accompanied by the following officers of the station: First Lieutenants Henry D. Hooker, Jr., and Carl H. Greene; Second Lieutenants Alfred Chanutin and Arthur H. Smith.

Dr. Pierre A. Fish, professor of physiology, and head of the physiology department of the college of veterinary medicine of Cornell University, has been commissioned a major in the Veterinary Corps, U. S. Army. He has been granted a leave of absence from the university for the duration of the war.

Alfred J. Larson, Ph.D. (Harvard), assistant professor of chemistry, Carleton College, has been in the chemical service of the government for a year and was recently commissioned as captain.

James Ewing, D.Sc. (Aberdeen), assistant professor of biology, Carleton College, has been since a year ago in the Canadian Army and is at present an instructor in the Canadian university back of the lines with the rank of sergeant.

Dr. Roswell P. Angier, professor of psychology at Yale University, is a captain in the Sanitary Corps, National Army, at the Hazelhurst Field Medical Research Laboratory, Mineola, L. I.

Assistant Professor Jacobs, of the zoological department of the University of Pennsylvania, has received a captain's commission in the Food Administration.

Professor Lightner Witmer, head of the department of psychology at the University of Pennsylvania, has returned from his work with the Red Cross in Italy and will be on active duty this year.

Information has been received through private sources to the effect that Professor Charles Barrois, well known to many geologists in the United States, is still in Lille and in good health. His movements have been restricted and no communication was held with

him by his friends in France; but he has been occupied in lecturing at the university to some young Frenchmen who were wounded at the time of the evacuation of the city four years ago and to others who have recovered from typhoid fever. As he could not undertake out-of-door studies, his attention has been turned to the paleontological material on hand in the museum collections. Professor Barrois now has the satisfaction of welcoming his compatriots after their recovery of Lille.

PROFESSOR L. R. CARY and Dr. Alfred C. Mayor have returned from an expedition of the department of marine biology of the Carnegie Institution of Washington to Samoa and Fiji. The expedition discovered that the growth-rate of Pacific corals is fully twice as fast as that of corresponding genera in the Atlantic. Also the occasional currents set toward the coast against the prevailing westerly drift of the surface waters of the Pacific are relatively acid in comparison with the water of the westerly drift.

PROFESSOR F. S. EARLE has gone to Porto Rico, where he is to investigate for the United States government a serious and rather obscure disease of sugarcane.

IN giving the teaching staff of the department of chemistry of the College of the City of New York in the issue of SCIENCE for October 4 the word "emeritus" was misplaced by a printer's error so that it occurred after the name of Professor Charles Baskerville, head of the department, instead of after the name of Professor L. H. Friedburg, who has retired after teaching in the college for some thirty years.

PROFESSOR ELLWOOD B. SPEAR, of the department of chemistry of the Massachusetts Institute of Technology, gave an illustrated lecture on "Some of the Problems of Gas Warfare" at the Brooklyn Institute of Arts and Sciences on October 19. Much of the material presented was first-hand experience since, as consulting expert to the Bureau of Mines, Professor Spear has dealt with problems of defense and offense, including gas masks and mustard gas.

DR. HERBERT G. KEPPEL, head of the department of mathematics at the University of Florida, died on October 5 at the age of fifty-two years. Dr. Keppel had been serving as a member of a National Commission to supervise the mathematics instruction given by the Y. M. C. A. at military camps, and while away from home on this duty contracted Spanish influenza, which resulted in his death.

LIVIC MORELLI, professor of medicine at the Pisa University, died on October 16, as the result of an infection contracted during a bacteriological research he recently conducted for the purpose of isolating the germ causing Spanish influenza.

The Journal of the American Medical Association states that at the request of the Surgeon-General of the U. S. Public Health Service, the officers of the American Public Health Association announce the postponement of their annual meeting, which was to have been held in Chicago October 14–17, to December 9–12, at the same place. This action was deemed advisable especially because it was considered unwise to ask sanitarians to leave their posts under present health conditions. Owing to the influenza epidemic prevalent throughout the country and the resultant increased demand for the services of doctors in their home communities, it has been considered advisable by the executive committee of the General Medical Board to cancel the meeting scheduled to be held in New York City at the Waldorf Astoria, on October 20. The regular annual session of the Clinical Congress of the American College of Surgeons, arranged for the week beginning October 21, has been cancelled for the same reason.

WE learn from the London *Times* that a royal commission has been appointed "to consider and report whether it is advisable to make any changes in the denominations of the currency and money account of the United Kingdom with a view to placing them on a decimal basis, and whether, if an alteration of the present system is recommended, it is desirable to adopt with or without modification the proposals embodied in the Bill recently introduced into the House of Lords by Lord Southwark or

some other scheme, and in the latter alternative to make specific recommendations for consideration by Parliament." The members of the Commission are: Lord Emmott, Lord Southwark, Lord Faber, Lord Ashton of Hyde, Lord Leverhulme, Sir Richard Vassar Vassar-Smith, Bt., Sir Joseph Larmor, Kt., Sir George Croydon Marks, Kt., Sir Alfred William Watson, Kt., Mr. John Westerman Cawston, C.B., Deputy Master and Controller of the Royal Mint; Mr. Sydney Armitage Smith, Mr. Charles Godfrey, headmaster, Royal Naval College, Osborne; Mr. James Bell, Mr. Joseph Burn, Mr. Harold Cox, Mr. George Hayhurst, Mr. Theodore McKenna, Mr. Geoffrey Marks, Mr. James Francis Mason, Mr. Abert Smith, Mr. George Murray Smith and Mr. Gilbert Christopher Vyle. Lord Southwark moved the second reading of his Coinage (Decimal System) Bill in the House of Lords on June 4. He said it had the support of Chambers of Commerce, the Institute of Bankers, the Decimal Association, and many scientific societies. Lord Hylton, for the government, offered a joint committee of both Houses, and the debate was adjourned. Early in July Lord Hylton, in reply to a question by Lord Southwark, announced the forthcoming appointment of this Royal Commission. The Treasury announces that, pending the appointment of a secretary to the Commission, communications may be addressed to "The Royal Commission on Decimal Coinage, Treasury Chambers, London, S.W. 1."

A special diploma course for the training of merchants in the woolen and worsted industry has been introduced at Leeds University, according to a report received from Consul Percival Gassett. The course includes work in textiles, economics and languages. It is proposed to use the fine equipment of the clothworkers' department of the university in giving the student knowledge of the materials, whether wools, tops, yarns, or fabrics, with which he is to deal, in order that he may learn intelligently the best means of producing goods to meet the requirements of each particular market. As for economics, it is intended to include not only economic geography, but also industrial history and accountancy with, if possible, lectures by leaders of the industry dealing with the special features of the larger commercial life. The language training will be so designed that while the literature of the various countries will not be overlooked, opportunity will be given for acquiring technical knowledge of the languages essential to particular industries. The following is the plan as approved by the university council: *First year:* Textiles, economic geography, a modern foreign language, and accountancy (prescribed subjects); and one of the following subjects: A second modern language, mathematics, European history, and industrial history. *Second year:* Textiles, economics, two modern foreign languages, and accountancy. *Third year:* To be spent at some colonial or foreign university or institution of university rank.

The objects sought by Brazil in establishing state zootechnic stations in Amazonas, Para, Maranhao, Ceara, Piauhy, Rio Grande do Norte, Alagoas, Sergipi, Espirite Santo, Parana, Goyaz and Matto Grosso are thus given in the order of the Minister of Agriculture quoted in the New York *Evening Post* authorizing such stations: (1) Acclimation and immunization of imported animals. (2) The breeding of pure-bred bovines, swine, goats and sheep. (3) The breeding of crossbred horses of native stock with Arabic, English or English-Arabic types when possible. (4) The selection of domestic types of animals, in respective states. (5) The raising of breeding animals, to be loaned upon a reasonable fee to farmers and breeders in the state. The zootechnic stations are obliged to possess: (*a*) An area of not less than 200 hectares (489 acres), of which 150 (371 acres) must be artificial pastures and 50 (123 acres) cultivated with forage; (*b*) proper installation, such as stables, cattle dips and similar apparatus; (*c*) a stock of not less than 3 horses, 8 bovines and 12 sheep and goats of such breeds as the Bureau of Animal Industry may direct. The zootechnic stations will be supervised by the director of the Bureau of Animal Industry. To obtain

government assistance, documents must be presented showing the existence of suitable lands and other facilities to maintain such establishments.

UNIVERSITY AND EDUCATIONAL NEWS

IT is planned to build a hospital on the campus of the University of Washington, Seattle, to cost a million dollars and which is to form the nucleus for a medical department of the university.

WILLIAM P. BROOKS, Ph.D., director of the Massachusetts Agricultural Experiment Station, has resigned his position. Dr. Brooks has been connected with the Massachusetts Agricultural College since 1889, previous to which he was professor of agriculture for twelve years in the Imperial College of Japan. He will continue in the service of the experiment station as consulting agriculturist.

PROFESSOR W. C. SABINE, acting director of the Jefferson Physical Laboratory of Harvard University, has retired and is succeeded by Professor Edwin H. Hall.

DR. PAUL F. GAEHR, of the department of physics at Wells College, has been appointed acting professor at Cornell University, where he will assist in the Students' Army Training Corps two days a week.

E. C. AUCHTER, associate professor of horticulture at the University of West Virginia, has been employed by the Maryland State College to head the department of horticulture.

ROBERT O. CALDWELL, Ph.D. (Princeton, '18) formerly professor of physics at Geneva College, has accepted a position as assistant professor of physics at West Virginia University.

THE following appointments have been made at Marquette School of Medicine: Mrs. Paul M. Smith, M.A. (Wisconsin), formerly assistant in botany at University of Wisconsin, as instructor in bacteriology. Mr. C. A. Hills, M.A., formerly instructor in physiology at the University of Kansas, now in charge of laboratory work in physiology and pharmacology, as instructor. Mr. A. H. Hersch, M.A., formerly instructor in biology at the Kansas State Agricultural College, as instructor in the department of anatomy and biology.

DISCUSSION AND CORRESPONDENCE

MR. ABBOT'S THEORY OF THE PYRHELIOMETER

TO THE EDITOR OF SCIENCE: Referring to Mr. Abbot's open letter to me, published in SCIENCE, June 21, 1918, I should like to make a few remarks. The important points can be taken as two, which require attention.

1. The first is that my research ranks as an "interesting speculation" without "quantitative value." After adapting the Boyle-Gay-Lussac Law, $P = \rho RT$, to atmospheric physics, the computations proceed by using only the standard formulas of thermodynamics, kinetic theory of gases, and electron physics; the checks are always complete and numerous; the results are in full agreement with observational data, so that Mr. Abbot's statement implies that these laws have no application in free atmospheres, which few will admit. The results have succeeded in clearing up a long series of heretofore unsolved problems, circulation, thermal data of various types from the adiabatic strata to the top of the various atmospheres, the origin of atmospheric electricity and magnetism, the thermodynamic environment of several spectra in the sun, and the end is not in sight. The Planck theory of radiation, the Bohr origin of spectrum lines, and the electron-atomic data are already seen from a new point of view. There are few computations whose data interpenetrate and are supported by so many distinct series of physical laws as are these, and the evidence is that they form the basis for future developments in atmospheric physics.

2. The second point is that Mr. Abbot reiterates this argument: that his well-known method of discussing the pyrheliometric observations must be correct, because it produces the same solar constant, 1.94 9^2. cal./cm.^{2} min., when repeated many times at many stations. If the method is erroneous it can not be made valid by repetition. It will be recalled that

Professor Langley deduced from his bolometer studies about 3.00 calories; that Angström and others obtained 4.00 calories, and those were common results for some years. Mr. Abbot reduced the value to 1.94 calories, relying solely upon the pyrheliometer, and at the same time recognized that the ordinates of the bolometric spectrum indicate a solar temperature of about 7000° A., the pyrheliometer requiring only 5800° A. He passed over this wide discrepancy by assuming that the sun does not radiate as a black body. This is the critical point. The Poynting equation of equilibrium asserts that the surface flux of radiation over a given volume sustains a certain volume density whose temperature is T. This equation has been applied by me in detail to the earth's atmosphere, so that in ten distinct integrations the volume density from the sea level to the vanishing plane amounts to 3.98 calories; it has been applied in the sun's atmosphere with the result that the solar radiation originates in a deep isothermal layer at the temperature 7655°. It is, therefore, black radiation, of an equivalent value of 5.85 calories; using Abbot's coefficients of transmission for several spectrum lines, from the center to the limb, this is depleted by 1.87 calories, thus agreeing with the terrestrial data and the bolometer. This result destroys Abbot's theory, and renders his pryheliometric method useless.

It is not difficult to understand the source of Mr. Abbot's error. He relies upon the Bouquer Formula of depletion, and, indeed, substitutes this for the Poynting Theorem, which is erroneous. When there is lack of equilibrium between the surface flux and the volume density, there is a product of free heat, $dQ = cdT$, while the temperature is changing. The pyrheliometer works on this change of temperature alone, omits to register the stored potentials and inner energy within the metals, glass, mercury, these last being very difficult to follow. In short, Abbot's theory identifies the surface flux of radiation with this free heat, and it follows that it does not manifest the entire radiation received. For these reasons I have abandoned Abbot's methods and substituted those found in my "Treatise on the Sun's Radiation." It may be noted that the pyrheliometer is a very inefficient apparatus for atmospheric studies, because it is unable to eliminate the depletions due to the effects of vapor, dust and even molecular scattering in the higher levels. Applying certain correcting ordinates, the stations at Cordoba-Pilar, 438 meters, and at La Quiaca, 3465 meters, are working together within 0.02 calories, and they follow the solar variations as indicated by the sun-spots, prominences, magnetic field and the meteorological data in Argentina. It is imperative that Mr. Abbot should abandon his unfortunate pyrheliometer method, which is flatly contradicted by a very extensive series of data, in favor of the results which are clearly indicated by his admirable observations with the bolometer.

Frank H. Bigelow

Solar and Magnetic Observatory,
Pilar, F. C. C. A., Argentina,
August 7, 1918

Fireflies Flashing in Unison

To the Editor of Science: In Science for July 26, 1918, there appears an article on "Fireflies Flashing in Unison," by Edward S. Morse. Confirming his statement and that of other observers that fireflies do at times synchronize their flashes I beg to relate an instance that occurred on the evening of May 4, 1918, on the Benguet road. At that time I was a passenger on the auto-stage run by the Philippine government between the railroad station at Mangaldan and Baguio. As the stage rounded one of the numerous curves on the grade there appeared on our left, apparently in motion, a ghostly incandescence which came and went in regularly repeated flashes and intervals of darkness. The appearance was uncanny and was plainly visible to all the passengers in the stage. We did not at first realize its cause but soon attributed it to fireflies. As I have said the light was apparently in motion, but I am inclined to believe that the insects which caused it were not in continuous flight but were congregated (as is frequently the case in the Philippines) about some tree standing

below us on the mountain slope and that the apparent motion was caused by the actual motion of the stage. At any rate there can be no doubt that the fireflies were flashing in unison.

FREMONT MORSE
Director of Coast Surveys
MANILA, P .I.

SCIENTIFIC BOOKS

The Passing of the Great Race. By MADISON GRANT. New York, Charles Scribner's Sons. 1918. Pp. 296.

It is rare that an author of a scientific work which is not a text-book has the pleasure of seeing a second edition within two years. Mr. Madison Grant's recent success is sufficiently justified, since he has written both boldly and attractively, and has produced a work of solid merit. Even the title, "The Passing of the Great Race," is of the sort to make a popular appeal, for there always seems to be an eagerness to read of some horrible future in store for mankind. Hence the success of books on degeneracy, race suicide, cessation of intellectual evolution, disgenic influence of war, and the elaborations of obvious pessimism—books and articles usually written by persons blind to the complexity of the problems and to the optimistic significance of facts and arguments on the other side.

Mr. Grant believes in the inborn value of the Nordic race, that tall, fair-haired, long-headed breed which started from the shores of the Baltic some three thousand years ago, formed the ruling classes in Greece, Rome, northern Italy, Spain, northern France, England and parts of the British Isles, and then, in the southern countries, passed away either through its inability to stand the climate in competition with brunette types, or through dilution and pollution of its blood by mixture with inferior peoples.

The present reviewer accepts, in the main, this racial theory of European historical anthropology. This theory rests upon two chief factors. The first is that so well elaborated by Mr. Grant in his book, namely, that it is supported by the facts of history. In other words, if we start with an extreme "hereditarian" hypothesis as to the special value of the Nordic race, we do write a good ethnological and anthropological history of European and Asiatic culture. The broad panoramic changes are systematically and reasonably explained by such an hypothesis. There is no shifting about—something relying on a theory and then having constantly to resort to some involved explanation because the theory has failed to work. In all this Mr. Grant's book is admirable; but it is open to criticism at the hands of opponents. The author rarely if ever discusses disputed points. For instance, he alludes frequently to the fact that in all European literature and art, the heroes, saints and madonnas have always been depicted as blondes, but he ignores the fact that its significance has often been questioned. In this matter, antagonists to the doctrines of heredity and to the native superiority of the blonde race usually say that the blonde type was admired because of its rarity. How is this to be answered? It is an affair of the author, not the reviewer.

In the last pages of his book, Mr. Grant gives a bibliography; but nowhere does he insert a footnote or give a reference to the sources of his information. While this may in some slight degree make the text more readable, it is a great pity that a reader can not more easily trace to their origins or further investigate many of the interesting and novel statements met with in this provocative book.

The second good reason for believing in the importance of inborn native mental differences, and consequently in the truth of most of what Mr. Grant asserts, is that there is a mass of carefully finished statistical research on the problem of human heredity which tends to support the whole theory of race as against environment. If adult human differences within a single family and within a single class are largely the result of pre-formed differences in the chromosomes of the primary germ cells, then there is at least a good hypothesis that the same is true for racial differences.

However, it requires further proof in the case of race, since the children of the same

families have a comparatively uniform environment, but different races necessarily carry with them each to some extent its own peculiar *milieu* We can not in our present knowledge assert how far this goes. Certainly races and indeed nations can be at least temporarily modified by an education and training imposed in the interests of, and by the will of, a very few persons, as for instance, Germany during the last half century.

This factor of leadership in the rise and decline of races is generally overlooked by Mr. Grant, as is the problem of the formation of upper classes. Mr. Grant fears that the Nordic race is passing away. There is much to be said in substantiation for this unpleasing prospect, and if there is much to be said, certainly Mr. Grant has said it. The present reviewer does not take such a gloomy view. There are internal forces silently and continuously working towards the improvement, not of the whole race, but of a part of it, and this part tends further to improve with its own improvement. Some of the tendencies or correlations working towards melioration are assortative mating (*i. e.*, tendency of like to mate with like), general truth as far as results at present indicate of desirable traits within an individual to be correlated with other desirable traits, general tendency of long-lived people with a tough resistance to leave more offspring than the average, besides other recently discovered correlations bringing an encouraging outlook.

There are some of the phases of human evolution that ought to be more generally recognized and incorporated into all discussions on the rise and decline of races and of nations.

In spite of such criticism, "The Passing of the Great Race" is an interesting and valuable pioneer attempt at an interpretation of history in terms of race. The origins and migrations of the three primary European races, Nordic, Alpine and Mediterranean, are here instructively and graphically portrayed. The colored charts make it easy to grasp the outlines of the author's theory. This is a book that will do much to widen the rapidly expanding interest in eugenics and help to disseminate the ever-growing conviction among scientific men of the supreme importance of heredity.

Frederick Adams Woods

War Bread. By Alonzo E. Taylor. New York, The Macmillan Co. 1918.

Almost since the outbreak of the war Dr. Taylor has been engaged in the study of the food problem, at first in Germany in the interest of British prisoners in German camps, then in Holland, making a survey of Dutch food resources, and he has later served as chief scientific adviser of the Food Administration of Washington and has made frequent trips to Europe. This little book, presenting as it does the cereal situation of the Allied countries in the spring of 1918, bids fair to become a classic. Reading it, one can realize how a fortunate wheat crop this year will allow us to send wheat to Europe directly without involving the increased number of ships necessary to transport it from far-away Australia or the Argentine. The book clearly shows how failure to conserve wheat plays into the hands of the enemy and tells of the methods employed for its conservation.

Graham Lusk

A STUDY OF ENGINEERING EDUCATION

The Carnegie Foundation for the Advancement of Teaching has just issued its Eleventh Bulletin, A study of Engineering Education, which has been in process of development during the past four years in cooperation with the joint committee on engineering education of the national engineering societies.

Engineering education was established on a large scale only fifty years ago on the basis of the experience of foreign countries, particularly France. Since then, applied science has made marvelous progress, and in order to meet that progress, the original curricula of the schools have been modified here and there and from time to time in a haphazard way. The result is that modern engineering curricula lack coherence and unity and have for a number of years been the object of criticism by the engineering profession.

Some ten years ago, the Society for the Promotion of Engineering Education appointed a committee to make a comprehensive study of the situation, and this committee associated with it delegates from the five great national engineering societies. This joint committee has been cooperating with the Carnegie Foundation in this study, and the bulletin just issued is the result of their united labors for the past four years. The bulletin was prepared by Dr. Charles R. Mann, formerly associate professor of physics in the University of Chicago, now chairman of the advisory board to the War Department committee on education.

The origin of the present system of engineering schools is traced in detail and its characteristics, both good and bad, are frankly stated. Its operation is studied mainly from the point of view of the effect upon the student and there is a careful examination of entrance records and college courses. as well as a brief summary of the current methods of instruction. On the basis of this analysis of the present situation, the larger problems of engineering education are considered to be those of admission, content and courses, faculty organization, and curriculum. The treatment culminates in a definition of each of the larger problems in terms of the requirements of the profession and of the young men who wish to enter. The chapters on admission and on testing and grading describe a series of new and original experiments carried out by Professor E. L. Thorndike, of Columbia University, in an effort to secure a more rational method of measuring engineering ability.

The constructive portion of the bulletin presents numerous suggestions as to ways and means of solving the problems thus defined, in an effort to reach the general principles which seem best qualified to help each school in solving the problem according to its own peculiar circumstances. Among the suggestions may be mentioned the necessity for more objective methods of rating and testing students and more accurate records of achievement; the need for closer cooperation among the several departments of instruction at each school; the introduction of practical experience with engineering materials into the freshman year; and the increase in the emphasis placed upon the humanities and humanistic studies.

The final chapter, entitled "the professional engineer," presents the results of an extended study of the demands of the engineering profession, and indicates that these demands can be fully met by the application of the principles that are developed in the preceding chapters. The thesis is set up that the chief lack in engineering education is the failure to recognize the importance of values and costs in all engineering work and suggests ways and means in which this idea may be emphasized to advantage both in the technical and the humanistic work. Engineering education is here shown to be but one branch of all education, and it is suggested that the methods of improving both are identical. Therefore, the bulletin has a wider interest than its title would imply and may be read with profit by educators of all kinds.

Copies of the Bulletin may be had by addressing the Carnegie Foundation, 576 Fifth Avenue, New York City.

TWO NEW ANTHROPOLOGICAL JOURNALS

DURING the present year two new anthropological journals have made their appearance—one devoted to physical anthropology, the other one devoted to American linguistics.

The establishment of the *American Journal of Physical Anthropology* is due to the energy of Dr. Aleš Hrdlička, curator of the division of physical anthropology in the United States National Museum. Up to the present time two numbers have appeared, which indicate that the scientific standard of the *Journal* will be a high one. The first number is introduced by a preface, and a general survey of the scope and aims of physical anthropology, both written by the editor Dr. Hrdlička. In the second number the editor gives a brief review of the history of physical anthropology in America. The department of literature is very full and exhaustive and gives a review of

all important publications that have appeared recently.

The second journal, *The International Journal of American Linguistics,* is edited by F. Boas and Pliny E. Goddard, with the assistance of Professor Uhlenbeck, of Leiden, and Dr. W. Thalbitzer, of Copenhagen. The first number of the journal contains a brief introduction setting forth the object of the journal. Special articles which have so far appeared deal with the languages of Central America and North America. In the reviews a summary of work done by the Bureau of American Ethnology is given.

F. B.

SPECIAL ARTICLES

THE RELATION OF THE PLANT TO THE REACTION OF THE NUTRIENT SOLUTION

One of the important factors to be considered in plant nutrition studies is the reaction of the nutrient solution. The determination of H ion concentration is of value, not only because of its general relation to plant growth, but also because of its bearing on the nature of selective absorption of ions. At the present time various misleading statements exist in the literature with regard to these points. In many cases principles which are elementary to the physical chemist have not been sufficiently appreciated by the agricultural chemist. In the course of extended studies conducted by this laboratory to determine some effects of concentration of the nutrient solution on plant growth and absorption, opportunity has been afforded for ascertaining the exact reaction of the nutrient media under widely varying and carefully controlled conditions. The purpose of the present article is the discussion in a preliminary way of this phase of the investigation.

It is a quite common impression that the plant by selective absorption may so alter the reaction of the nutrient solution as to produce extreme alkalinity or acidity. For example, Palladin[1] in describing water culture experiments states:

[1] Palladin, W., "Pflanzen physiologie," Berlin, 1911, p. 82.

Während der Vegetation muss dafür gesorgt werden, dass die Kultur flüssigkeit nicht alkalisch wird. Zur Beseitigung der alkalischen Reaktion wird so lange schwache Phosphorsäurelösung zugesetzt, bis die Lösung schwach sauer reagirt.

Also it is often claimed that from KCl, K_2SO_4, and similar solutions the cation is removed at a rate so much faster than that of the anion that a marked acid reaction ensues, which may result in injury to the plant. Conversely a $NaNO_3$ solution is said to become alkaline. The evidence on which these ideas are based is very slight. Some of the experiments quoted were performed many years ago, when chemical methods and principles were in a relatively imperfect stage of development. The condition of acidity of alkalinity in most of the investigations has been measured by various titrations, which for this purpose are subject to misinterpretation, as pointed out in a previous article.[2]

In the latter investigation experiments with barley seedlings indicated a strong tendency on the part of the plant to change the reaction of various potassium phosphate solutions in the direction of neutrality; either acid or alkaline solutions soon attained a H ion concentration equivalent to approximately P_H 7.0, while neutral solutions remained unaltered in reaction. These experiments have now been extended to other solutions including complete nutrient solutions, and observations have been made at all stages in the growth cycle of the barley plant. Also several varieties of beans have been used. The experiments were carried out by means of sand and water cultures, which will be described elsewhere. It will suffice to state here that the technique was such as to permit of the production of normal, well matured plants. In every instance, without exception, nutrient solutions with an acid reaction reached an approximately neutral reaction after contact with the plant roots for varying periods of time. Even where plants were grown to maturity without change of solution, the neutral

[2] Hoagland, D. R., "Soil Science," Vol. III., No. 6, pp. 547–560, 1917.

reaction remained constant throughout the entire period. The data from a number of typical experiments are presented below. H ion concentrations were usually determined colorimetrically, with the methods and indicators described by Clark and Lubs.[3]

TABLE I

Description of Plant	Solution	Time of Contact	Reaction at Beginning, P_H	Reaction After Contact with Plant, P_H
Barley grown to maturity. No change of solution	Complete nutrient 1500 p.p.m.	4 mos.	6.8	6.9
Barley 6 weeks	Complete nutrient 2500 p.p.m.	1 week	5.6	6.8
Barley 7 weeks	Complete nutrient 1500 p.p.m.	22 hrs.	5.1	6.1
Barley 7 weeks	Complete nutrient 1500 p.p.m.	36 hrs.	5.1	6.8
Barley 7 weeks	Complete nutrient 5000 p.p.m.	50 hrs.	5.0	6.1
Barley 7 weeks	Complete nutrient 5000 p.p.m.	96 hrs.	5.0	6.5
Barley grown to maturity	Complete nutrient 300, 1000, 2500 p.p.m.	12 weeks	6.8	6.5–7.2

Chemical analyses of the solutions made it clear that the change in reaction had been the result of selective absorption from the various phosphoric acid anions, accompanied by an equivalent removal of positive ions. A marked regulatory absorption is apparent.

Other experiments were made in which barley plants were grown for seven weeks in favorable nutrient solutions and then transferred (after thoroughly washing the roots in distilled water) to solutions of KCl, K_2SO_4, $MgSO_4$, K_3PO_4, NH_4Cl and $NaNO_3$. The reactions of the solutions were tested after varying periods of contact from a few hours to forty days. In no case was a condition either of excessive OH ion or H ion concentration produced, although absorption had been active. The acid reaction when present was due to slightly dissociated acids, usually carbonic, or to acid salts in the case of the NH_4Cl solution. Possibly in some cases organic acids were formed.

[3] Clark, W. M., and Lubs, H. A., *Jour. Biolog. Chem.*, Vol. XXV., No. 3, pp. 479–510, 1916.

TABLE II

Salt Used. (Concentration 1,500 p.p.m.)	Time of Contact	Per Cent. of Salt Absorbed (by Conductivity)	Reaction After Contact, P_H	Reaction Solution After Heating, P_H
KCl	39 days	42.6	5.3	6.5
$NaNO_3$	39 "	56.5	7.2	9.5
$MgSO_4$	16 "	22.9	6.5	7.0
K_2SO_4	16 "	36.8	6.3	7.0
K_3PO_4(1)	16 "	33.0	7.5	—
NH_4Cl(2)	8 "	30.0	5.0	—

P_H original solutions (1) 10.3, (2) 5.7.

Barley plants grown seven weeks in complete nutrient solutions.

Very striking is the change induced in the K_3PO_4 solution. From a condition of intense alkalinity the solution became approximately neutral. The NH_4Cl solution retained an acid reaction. This would necessarily be the case as long as any NH_4Cl remained unabsorbed. The H ion concentration was slightly increased after contact with the plant, but less than would occur if even 1 p.p.m. of residual HCl were formed. Analysis of the solution showed a considerable absorption of both ions, but about 5 per cent. more NH_4 than Cl was removed. The balance was restored, however, by the excretion from the plant of equivalent quantities of other bases, chiefly calcium. There is no evidence that NH_4OH was absorbed with the formation of a residue of HCl. At least neither the analysis nor the reaction indicates that the absorption took this course.

After boiling the $NaNO_3$ solution gave an OH ion concentration similar to that produced by the hydrolysis of Na_2CO_3. The residual solutions of $NaNO_3$ and KCl were analyzed with the following results.

From the above it may be inferred that part of the NO_3 was removed simultaneously with an equivalent quantity of Na, but more NO_3 than Na was absorbed, HCO_3 ion entering or being formed in the solution to restore the

TABLE III

Analyses of Solutions

	$NaNO_3$ Solution				KCl Solution			
	At Beginning	After Contact with Plant	Absorption by Plant	Per Cent. Absorption	At Beginning	After Contact with Plant	Absorption by Plant	Per Cent. Absorption
	p.p.m.	p.p.m.	p.p.m.		p.p.m.	p.p.m.	p.p.m.	
Ca	....	11	....		....	14	...	
Mg	....	...	....		....	2	...	
K	....	...	....		1380	812	568	41.1
Na	690	329	361	52.3	....	...	...	
HCO_3	....	517	....		....	15	...	
Cl	....	...	....		1248	732	516	41.3
NO_3	1860	335	1525	81.9	....	...	...	

Barley plants grown seven weeks in complete nutrient solutions.

Contact with $NaNO_3$ and KCl solutions 39 days.

balance. This ion in equilibrium with dissolved CO_2 brought about a neutral reaction in the solution actually in contact with the plant. From the KCl solution K and Cl were absorbed in equivalent quantities. On the basis of these results it is clear that the selective action for NO_3, while it does not of itself cause any injurious reaction, might eventually give rise to an alkaline condition in the soil as a result of the accumulation of Na_2CO_3. This is in accord with the usual conception. However, it is not easy to reach the conclusion that KCl, K_2SO_4, etc., could bring about an acid reaction in a similar manner. That such a result actually occurs in the soil as the result of salt treatments has been shown by Sharp and the author[4] and by Plummer,[5] but the increase in the intensity of acidity may be ascribed to interreactions in the chemical system of the soil, irrespective of plant absorption.

The extensive analyses of Pantanelli[6] would indicate that in the case of almost every salt, after a few hours contact, the plant has absorbed more of one ion than the other. Nevertheless in the periods of time in question only minute quantities were removed and the exchange of ions between the plant and solution was not excluded from consideration. The researches of Nathanson[7] show the possibility of such an exchange. For example, the absorption of NO_3 by certain algæ may be accompanied by a loss of Cl from the plant. Nathanson emphasizes the necessity of a state of equilibrium in the solution and it is self-evident that the equivalence of positive and negative ions must be maintained. Thus, if K is to be selectively absorbed from a KCl solution it must be as KOH, with a residue of HCl. The determinations of reaction and analyses of residual solutions are not in favor of this mechanism. It would seem the final result must be either the equivalent absorption of both ions or the exchange of ions between plant and solution. In a complex nutrient solution or in the soil unlimited possibilities of combination exist.

It is true of course that much evidence has been adduced by Pantanelli, Nathanson and others in support of the hypothesis of the absorption of ions as such, but no evidence obtained from a study of the nutrient solution seems capable of conclusively demonstrating the precise mechanism of the intermediate steps in the absorption. In this general connection the universally known work of Loeb and Osterhout bearing on the ionic nature of antagonism will be recalled. In any case, whether molecular or ionic absorption or ionic exchange is concerned the resultant solutions do not attain a concentration of H ion or OH ion indicative of the presence of highly dissociated acids or bases, while in complex nutrient solutions an approximately neutral reaction is produced as a result of absorption by the plant.

II

The nature of acid soils and their relation to crop growth have been among the topics most widely discussed by soil chemists. The common occurrence of soils distinctly acid (in the physical chemical sense) has been pointed

[4] Sharp, L. T., and Hoagland, D. R., *Jour. Agr. Res.*, Vol. VII., No. 3, pp. 123–145, 1916.

[5] Plummer, J. K., *Jour. Agr. Res.*, Vol. XII., No. 1, pp. 19–31, 1918.

[6] Pantanelli, E., *Jahrb. f. wissen. Botanik*, Vol. 56, pp. 689–733, 1915.

[7] Nathanson, A., *Jahrb. f. wissen. Botanik*, Vol. 38, pp. 241–290, 1902–03; Vol. 40, pp. 403–442, 1904; Vol. 39, pp. 607–644, 1903–04.

out by Gillespie[8] and by Sharp and the author.[4,9] Recently Plummer[5] has confirmed these views and presented much additional data. It is often assumed that most agricultural plants require a slightly alkaline reaction in the soil. Previous work has shown that a reaction of PH 5.0 is in no way inhibitive to the growth of barley seedlings. This point has been investigated further, with the use of several varieties of beans in sand cultures. The solutions were changed with sufficient frequency to maintain constantly an acid reaction. No evidence of injury was apparent. Truog[10] upholds the view that the acidity per se is not ordinarily the limiting factor in acid soils.

With reference to the latter point it may be of interest to present some observations made on an area of California peat soils. All were found to be decidedly acid, as follows:

TABLE IV

P_H of Soil Suspensions

Description of Soil	P_H
1. Surface, never cropped	5.4
1a. Subsoil from above	6.0
2. Surface, cropped 15 years	4.9
2a. Subsoil from above	4.9
3. Surface, 2 years in potatoes	5.1
3a. Subsoil from above	4.6
4. Surface, barley field	4.5

In sections where other inhibiting factors were absent first class crops of barley, oats, beans, potatoes, onions, corn, asparagus, etc., were produced. Incidentally it may be mentioned that from 100 to 3,000 p.p.m. of NO_3 (basis of dry soil) were found. It is evident that in these soils the acid reaction did not interfere with the growth of crops nor the formation of nitrates.

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[8] Gillespie, L. J., *Jour. Wash. Acad. Sci.*, Vol. 6, No. 1, pp. 7–16.

[9] Hoagland, D. R., and L. T. Sharp, *Jour. Agr. Res.*, Vol. XII., No. 3, pp. 139–148, 1918.

[10] Truog, E., *Soil Science*, Vol. 5, No. 3, pp. 169–196, 1918.

AN ELECTRO-THERMO-REGULATOR FOR WATER BATHS

THE majority of electro-thermostats so far devised and in use in paraffin ovens, incubators and control chambers have been constructed to operate directly in the chamber itself. Such installation is not wholly desirable, inasmuch as a regulator so placed is subjected to sudden and extreme variations of temperature each time the door or compartment is opened. This not only interferes with the stability and accurate operation of the instrument itself, but causes an unnecessary number of "makes" and "breaks" on the part of the mechanism, with its attendant corrosion of the contact points, and is also conducive to fluctuations in the temperature caused by the unnecessary heating and slow cooling of the heating element. The thermo-regulator herewith described is designed to be inserted in the tubulature of the incubator, where it is immersed in the water of the water jacket. It is intended to be used in connection with a secondary switch in circuit with an electric heating element. So employed, and with a moderate current passing through the primary circuit, the thermostat will give continuous control within a fraction of a degree of the specified temperature.

The thin brass casing *C* is 29.5 cm. long by 2.5 cm. outside diameter. It is strengthened at its upper end by a collar *D*, which extends on one side to form a rigid arm *A*. Binding posts *B* and *B'* are for wires leading to the secondary switch, which is placed in some out-of-the-way situation. They are thoroughly insulated from the arm *A* by red fiber composition. Binding post *B'* is bolted securely to a curved saddle-piece *S*, in which is suspended a bent lever *L*. Platinum points *P* and *P'* of generous size are soldered to binding post *B* and lever *L* respectively, while a no. 3 cover glass *T* is cemented with hard shellac to the vertical arm of the lever, insulating it from the rest of the mechanism.

The thermostat operates on the principle of the unequal expansion of two different metals composing a couple. Zinc and iron make a sensitive combination; but lead and iron, alu-

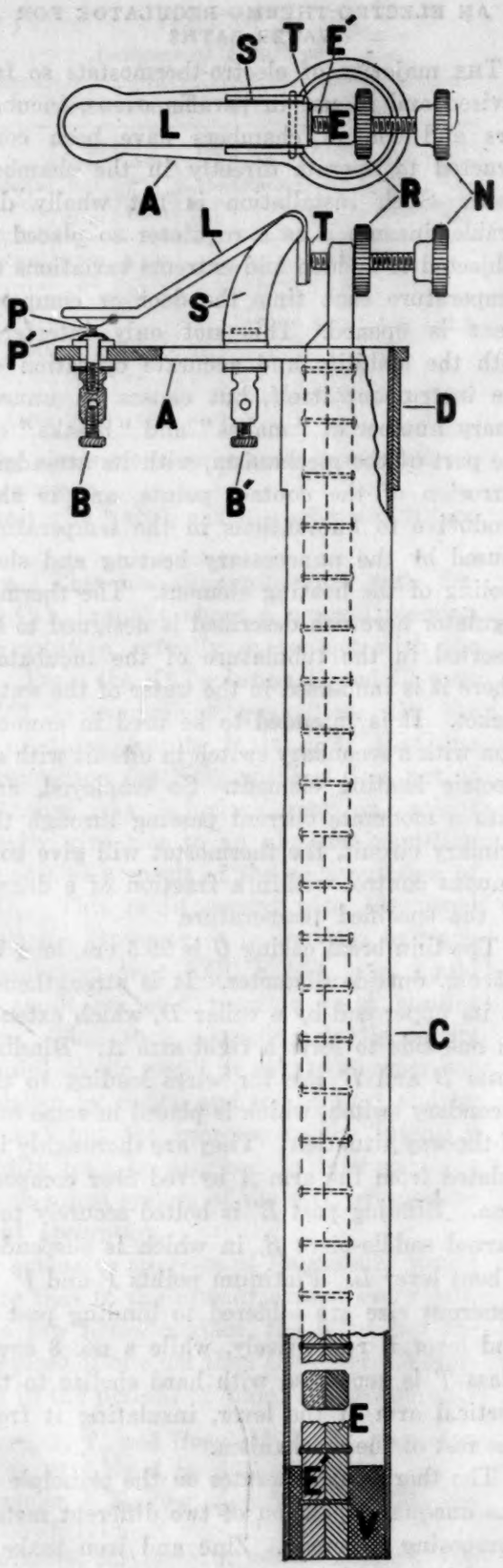

Fig. 1.

minum and iron, copper and iron and other combinations may be used, except that there is a loss in sensitiveness in the order indicated. Two pieces or strips E and E', each about 9.0 mm. in width and 6.0 mm. thickness are riveted together and imbedded in solder V at the bottom of the casing. A screw N and locknut R provide means of adjustment of the parts. This method of construction makes a rigid column which is not subject to the vibrations common in a laboratory. In practise, the casing is filled with glycerin, which increases the continuity of parts and prevents corrosion of the metallic couple.

The advantages of this design other than those already mentioned are apparent. First, the generous length of the metallic couple insures a maximum of sensitiveness. Second, this sensitiveness is further increased by the mechanical advantage of the lever. Third, continued movement of the bimetallic column in either direction imposes no strain upon any of the parts of the mechanism, a feature not incorporated in thermostats to be found on the market, and one which makes possible accurate control with least adjustment for long and continuous periods of time.

In the construction and testing of this thermostat, the writer is indebted to the New Hampshire College and Experiment Station for the use of laboratories and equipment.

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